



PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : G03F 7/42, H01L 21/306, 21/311, 21/3105	A1	(11) International Publication Number: WO 97/36209 (43) International Publication Date: 2 October 1997 (02.10.97)
(21) International Application Number: PCT/EP97/01190 (22) International Filing Date: 10 March 1997 (10.03.97) (30) Priority Data: 96104613.3 22 March 1996 (22.03.96) EP (34) Countries for which the regional or international application was filed: GB et al. (71) Applicant (for all designated States except US): MERCK PATENT GMBH [DE/DE]; Frankfurter Strasse 250, D-64293 Darmstadt (DE). (72) Inventors; and (75) Inventors/Applicants (for US only): LIAW, Ming-Chi [---]; No. 1001-1, Ta Hsueh Road, Hsinchu City (TW). CHAO, Tien-Sheng [---]; (TW). LEI, Tan-FU [---]; No. 1001-1, Ta-Hsueh Road, Hsinchu City (TW). (74) Common Representative: MERCK PATENT GMBH; Frankfurter Strasse 250, D-64293 Darmstadt (DE).		(81) Designated States: CA, CN, CZ, HU, JP, KR, RU, SG, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: SOLUTIONS AND PROCESSES FOR REMOVAL OF SIDEWALL RESIDUE AFTER DRY-ETCHING		
(57) Abstract <p>The present invention relates to a novel process for removing sidewall residue after dry-etching process. Conventionally, after dry-etching, photoresist and sidewall residues are removed by ozone ashing and hot sulfuric acid. Normally, they are hard to be removed completely. It was found in the present invention that the addition of fluorine-containing compound, preferably hydrogen fluoride and ammonium fluoride, in sulfuric acid results in complete removal of photoresist and sidewall residue without the need for stripper. The process is simple and does not affect the original procedures or the other films on the substrate. The present invention also relates to a novel solution for removing sidewall residue after dry-etching, which comprises sulfuric acid and a fluorine-containing compound, preferably hydrogen fluoride and ammonium fluoride, in the range of from 10:1 to 1000:1 by weight.</p>		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon	KR	Republic of Korea	PL	Poland		
CN	China	KZ	Kazakhstan	PT	Portugal		
CU	Cuba	LC	Saint Lucia	RO	Romania		
CZ	Czech Republic	LI	Liechtenstein	RU	Russian Federation		
DE	Germany	LK	Sri Lanka	SD	Sudan		
DK	Denmark	LR	Liberia	SE	Sweden		
EE	Estonia			SG	Singapore		

Solutions and Processes for Removal of Sidewall Residue after Dry Etching

Background of the Invention

5 Scope

The present invention relates to a novel process for removing sidewall residue after dry etching. The present invention also relates to a novel solution for removing sidewall residue after dry etching.

10

Current State of the Art

Processes of Integrated Circuit (IC) Manufacturing:

15

First is deposited a layer of metal, such as Al, on a substrate surface, such as a wafer, then coating a layer of photoresist on it. This is followed by exposure, developing, etching, ion implantation and photoresist removing. Continuous cycles of film deposition, photoresist coating, exposure, developing, etching and removal of photoresist continue until the desired device is achieved.

20

25

There are two kinds of photoresist: positive type and negative type. For positive type photoresist, the area of exposure can be dissolved in developer solution. For negative type photoresist, the area of non-exposure can be dissolved in developer solution. The major composition of positive photoresist is resin, such as Novolac resin. The major composition of negative type photoresist is polyisoprene compound. Generally, baking the photoresist layer after exposure is necessary to make sure that cross-linking reaction is done.

30

35

After creating basic IC pattern and more sophisticated IC pattern is to be processed on the substrate, the photoresist and sidewall residue must be removed very efficiently and completely. That is by the use of a photoresist stripper, as in US Patent No. 4,917,122 and 4,963,342 described.

In the etching process of VLSI (Very Large Scale Integrated) or ULSI (Ultra Large Scale Integrated) manufacturing, sidewall passivation formed after dry etching can achieve the anisotropic phenomena of etching process, as in J.L. Vossen, et al, J. Vac Sci. Technol. AL. 1453 (1983); J.H. Thomas, et al, Appl. Phys. Lett. 43, 859 (1983), D. Thomson, et al, Appl. Phys. Lett. 146, 1103 (1985), and J.M.E. Harper, et al, J. Electrochem. Soc. 128, 1077 (1981) described. While etching Poly-Si, according to the etching chemistry of Cl_2 or HBr , oxygen is added to enhance anisotropic tendency and selectivity to oxide layer, as in I. Morimoto et al, Digest of papers, Microprocess 202 (1992) described. While etching Poly-Si layer using Cl_2 as etching gas, silicon reacting with chlorine becomes silicon chloride. If oxygen exists, silicon chloride will be oxidized to silicon oxide, as in K.V. Guinn et al, J. Vac. Sci. Technol. B 13, 214 (1995) described. This silicon oxide is the so-called sidewall passivation, which can prevent isotropic etching. The sidewall passivation cannot be removed completely by conventional ozone ashing and hot sulfuric acid process. In the general process, wafers after treatment of ozone ashing and hot sulfuric acid still need to be immersed in diluted HF solution. The time of immersion cannot last too long to avoid attacking bottom oxide layer. Although the residue can be removed by special stripper, it is not convenient enough. Therefore the process of removing sidewall residue after dry etching should be improved.

Summary of the Invention

The present invention relates to a novel solution in which a certain amount of fluorine-containing compound, preferably hydrogen fluoride and ammonium fluoride, is added into sulfuric acid. This solution can completely remove sidewall residue which is formed after dry etching.

The invention also relates to a novel process by which sidewall residue after dry etching can be completely removed by the above mentioned novel solution.

Brief Description of the Drawings

Fig. 1 shows the flow chart of the conventional and the novel process used in IC manufacturing process. Fig. 2 shows the magnified picture of a wafer treated with the conventional process and the magnification is 13,100 times.

Fig. 3 shows the magnified picture of a wafer treated with the novel process and the magnification is 11,000 times.

Detailed Description of the Invention

The processes of IC manufacturing can be described as follows. First of all, cleaning wafer surface, then depositing SiO_2 and Poly-Si films on it. After that, photoresist coating, exposure, developing, etching and photoresist stripping processes are done. Fig. 1 shows the flow chart of the process.

Conventionally photoresist and sidewall residue are removed by ozone ashing and hot sulfuric acid, but they cannot be removed completely (Fig. 2). Following immersion into diluted HF solution or special strippers is required.

The present invention is a process on which by addition of fluorine-containing compound into sulfuric acid, controlling the ratio of sulfuric acid to fluorine-containing compound, complete removal of sidewall residue without the need for diluted HF and special strippers can be achieved (Fig. 3). The process is simpler and can reduce process steps to only one. Fig. 1 shows the flow chart of the process.

The invention uses a novel solution to remove sidewall residue formed after dry etching, which comprises sulfuric acid and a fluorine-containing compound, in the range of from 10:1 to 1000:1 by weight, preferably in the range of from 100:1 to 700:1, most preferred in the range of from 300:1 to

500:1. The fluorine-containing compound is composed of fluorine ion and mono-charge cation, such as alkaline metal cation, ammonium cation and hydrogen ion, preferably hydrogen fluoride and ammonium fluoride. The novel solution is prepared by adding hydrofluoric acid or ammonium fluoride into sulfuric acid, and then mixing it with hydrogen peroxide at temperature 100-140 °C, preferably 120 °C. The above mentioned chemicals can be commercially available ones like H₂SO₄ 96 %, H₂O₂ 31 %, HF 49 %, NH₄F 40 %.

While using the new process to remove sidewall residue after dry etching, both organic and inorganic, such as SiO₂, compounds can be removed. It can be implemented without increasing difficulty of the process. Just after dry etching and ozone ashing, put wafer into the pre-mixed solution of sulfuric acid and fluorine-containing compound, and maintaining operation pressure at 1 atm, temperature at 00-140 °C (preferably 120 °C) for 10 min. The photoresist and sidewall passivation formed after dry etching can be removed completely and the novel solution does not affect the film of poly-Si, and only slightly etching the bottom oxide layer (less than 1 Å/min). After dry-etching process, the wafer is put into the reaction chamber in which the ozone ashing process is done. During this process, ozone decomposes into oxygen and oxygen atoms which react with large amounts of carbon atoms in the photoresist under high temperature condition and then form CO₂. By detecting the amount of CO₂ one can know whether ozone ashing reaction completes or not.

The new process is simple, speedy, and does not need to use strippers or other solutions any more. Manufacturing cost for IC devices can be reduced significantly. Both feasibility and practicability of this new process are high. The process is suitable for several kinds of photoresists including g-line, i-line, Deep UV, E-beam and X-ray resists.

The following examples are further explanations of the invention. However, the scope of this invention is not limited to these examples. All possible substitutes and adjustments done by people who are familiar with this technique are belonging to the application and range of this invention.

Example 1

The photoresist used in the process is FH-6400L g-line photoresist (Fuji-Hunt). Exposure is done by PAS 2500/10 g-line stepper (ASM). Developer used in the process is FHD-5 developer containing TMAH 2.38 % (Fuji-Hunt). Developing time is 60 sec. The ECR (Electron Cyclotron Resonance) etching machine is used for etching 3000Å of Poly-Si. The plasma is produced by using Cl₂ (95 sccm), O₂ (5 sccm) and 250 W microwave. DC Bias is provided by 35 W of RF. Pressure in the chamber is 3 mTorr while temperature is -20 °C. Etching time is 70 sec. The etching rate for Poly-Si is 2612 Å/min for Poly-Si, 26 Å/min for SiO₂, 766 Å/min for photoresist. As for selectivity, the ratio of Poly-Si to SiO₂ (2612/26) is 100 while Poly-Si to photoresist (2612/766) is 3.4.
(sccm - standard cubic centimeter per minute)

Comparative Example

After dry etching, conventional process is used to remove photoresist. At first, the photoresist is removed by ozone ashing which is done inside the chamber, one wafer per time at temperature of 200-300 °C. At this temperature, decomposed oxygen from ozone reacts with the carbon of photoresist and forms CO₂. Then the wafer is immersed into mixed solution of sulfuric acid and hydrogen peroxide at 120 °C for 10 min. After this treatment, the wafer is inspected by SEM (Fig. 2). At this stage, only photoresist can be removed while sidewall passivation after dry etching cannot be removed completely. Diluted HF or special stripper is needed for further treatment.

Example 2

After dry etching, present novel process is used to remove photoresist. At first, photoresist is removed by ozone ashing which is done in the same way as the comparative example. Then the wafer is immersed into mixed solution of sulfuric acid, hydrofluoric acid and hydrogen peroxide at 120 °C

for 10 min. The ratio of sulfuric acid + hydrofluoric acid to hydrogen peroxide is 3:1 by volume. After this treatment, the wafer is inspected by SEM (Fig. 3). It is obvious that photoresist and sidewall passivation after dry etching are removed completely by this single step without affecting Poly-Si and bottom SiO₂ layer.

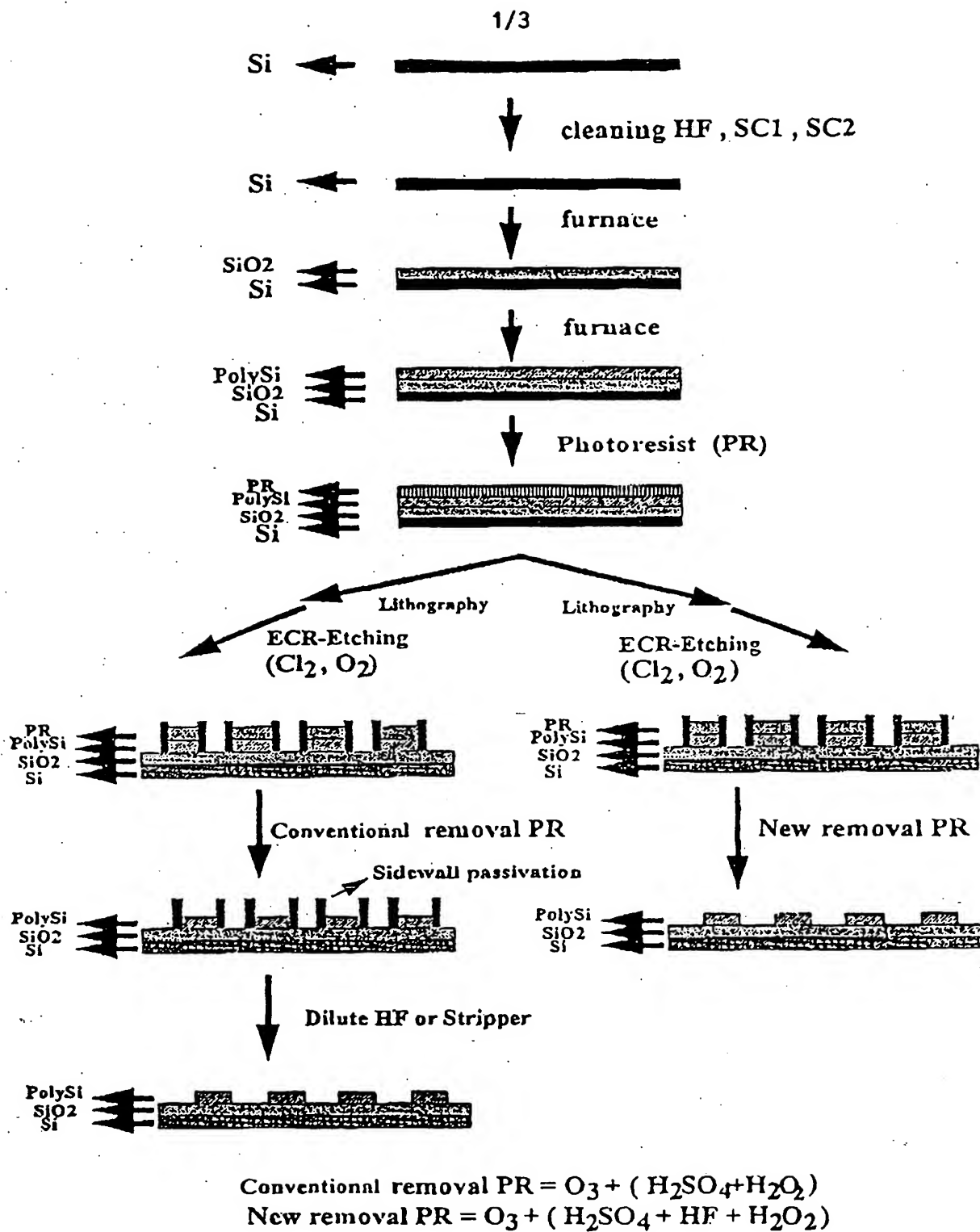
Example 3

After dry etching, present novel process is used to remove photoresist. At first, photoresist is removed by ozone ashing which is done in the same way as the comparative example. Then the wafer is immersed into mixed solution of sulfuric acid, ammonium fluoride and hydrogen peroxide at 120 °C for 10 min. The ratio of sulfuric acid + ammonium fluoride to hydrogen peroxide is 3:1 by volume. After this treatment, the wafer is inspected by SEM. It is obvious that photoresist and sidewall passivation after dry etching are removed completely by this single step without affecting Poly-Si and the bottom SiO₂ layer.

Claims

1. A solution for removing sidewall residue after dry etching, which comprises sulfuric acid and a fluorine-containing compound, in the range of from 10:1 to 1000:1 by weight.
2. The solution according to claim 1, the range being from 100:1 to 700:1 by weight.
3. The solution according to claim 1, the range being from 300:1 to 500:1 by weight.
4. The solution according to claim 1, the solution containing a fluoride compound, which is composed of fluorine ion and mono-charge cation, the types of this mono-charge cation include alkaline metal cation, ammonium cation and hydrogen ion.
5. The solution according to claim 1, the fluorine-containing compound being hydrogen fluoride.
6. The solution according to claim 1, the fluorine-containing compound being ammonium fluoride.
7. A process for removing sidewall residue after dry etching in which wafer after dry etching is treated with a solution which comprises sulfuric acid and a fluorine-containing compound, in the range of from 10:1 to 1000:1 by weight.
8. The process according to claim 7, the solution being in the range of from 100:1 to 700:1 by weight.

- 5
- 10
- 15
- 20
- 25
- 30
- 35
9. The process according to claim 7, the solution being in the range of from 300:1 to 500:1 by weight.
 10. The process according to claim 7, the fluorine-containing compound is composed of fluorine ion and mono-charge cation, the types of cation include alkaline metal cation, ammonium cation and hydrogen ion.
 11. The process according to claim 7, the fluorine-containing compound being hydrogen fluoride.
 12. The process according to claim 7, the fluorine-containing compound being ammonium fluoride.

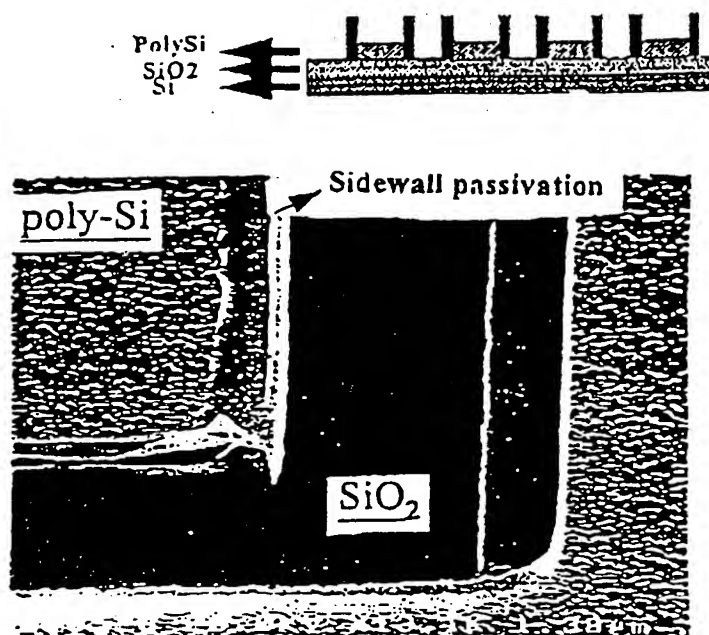


(Fig. 1)

(Fig.2)

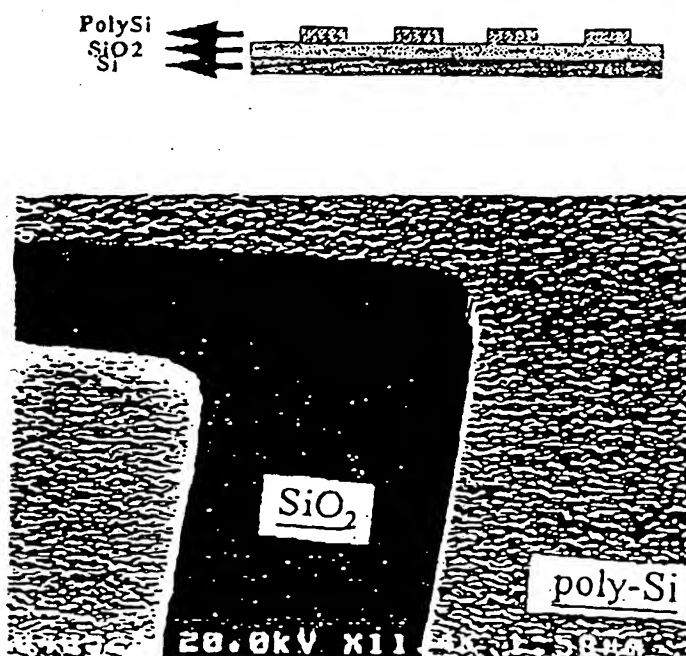
2/3

Conventional removal PR = $O_3 + (H_2SO_4 + H_2O_2)$

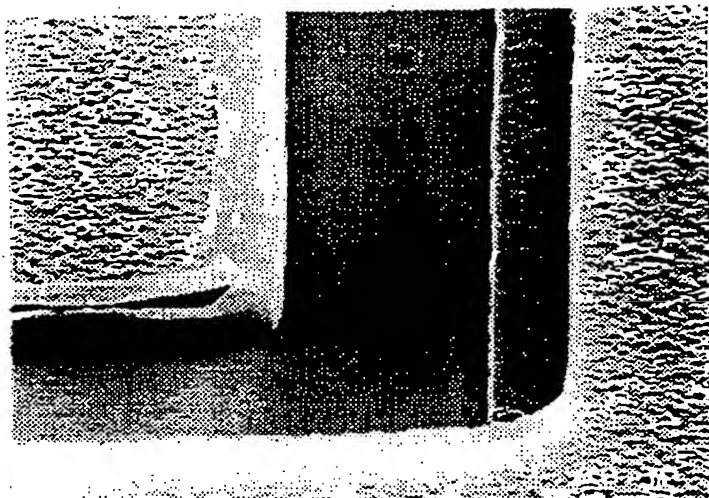


(Fig.3)

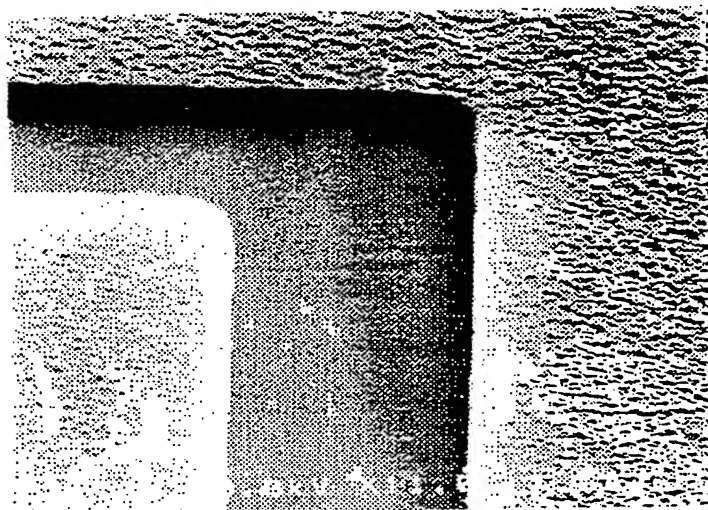
New removal PR = $O_3 + (H_2SO_4 + HF + H_2O_2)$



Figur 2



Figur 3



INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 97/01190

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G03F7/42 H01L21/306 H01L21/311 H01L21/3105

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G03F H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE INSPEC INSTITUTE OF ELECTRICAL ENGINEERS, STEVENAGE, GB Inspec No. 5169464, VERHAVERBEKE S ET AL: "Improved rinsing efficiency after SPM (H/sub 2/SO/sub 4/-H/sub 2/O/sub 2/) by adding HF IC surface cleaning" XP002035581	1-5,7-11
Y	see abstract & PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON ULTRA-CLEAN PROCESSING OF SILICON SURFACES (UCPSS '94), PROCEEDINGS OF ULTRACLEAN PROCESSING OF SI SURFACES '94, BRUGES, BELGIUM, 19-21 SEPT. 1994, ISBN 90-334-3262-5, 1994, LEUVEN, BELGIUM, ACCO, BELGIUM, pages 201-204, --- -/--	6,12

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

18 July 1997

Date of mailing of the international search report

11.08.97

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+31-70) 340-3016

Authorized officer

Philosoph, L

INTERNATIONAL SEARCH REPORT

Intern. Application No.
PCT/EP 97/01190

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>DATABASE INSPEC INSTITUTE OF ELECTRICAL ENGINEERS, STEVENAGE, GB Inspec No. 3071502, TOMAIUOLO F: "Tests for vitriolic re-etching by raster electron microscope (multilayer PWB fabrication)" XP002035582 see abstract & FINOMMECHANIKA - MIKROTECHNIKA, APRIL-MAY 1986, HUNGARY, vol. 25, no. 4-5, ISSN 0324-7007, pages 103-108,</p> <p style="text-align: center;">---</p>	1-12
X	<p>DATABASE INSPEC INSTITUTE OF ELECTRICAL ENGINEERS, STEVENAGE, GB Inspec No. 5169485, ROTONDARO A L P ET AL: "Interaction of the sulphuric acid hydrogen peroxide mixture with silicon surfaces" XP002035583 see abstract & PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON ULTRA-CLEAN PROCESSING OF SILICON SURFACES (UCPSS '94), PROCEEDINGS OF ULTRACLEAN PROCESSING OF SI SURFACES '94, BRUGES, BELGIUM, 19-21 SEPT. 1994, ISBN 90-334-3262-5, 1994, LEUVEN, BELGIUM, ACCO, BELGIUM, pages 301-304,</p> <p style="text-align: center;">---</p>	1-12
X	<p>INTERMETALLICS, vol. 3, - 1995 pages 173-186, XP002035580 SHYAM P. MURARKA: "Silicide thin films and their applications in microelectronics"</p> <p style="text-align: center;">---</p>	1,4,5,7, 10,11
Y	<p>see page 181, paragraph 21; table 6</p> <p style="text-align: center;">---</p>	6,12
X	<p>EP 0 346 668 A (MICRO IMAGE TECHNOLOGY LTD) 20 December 1989 see claims 1-3,6,11,13; examples 1-18</p> <p style="text-align: center;">---</p>	1-3,7-9
X	<p>US 5 294 570 A (FLEMING JR MARSHALL J ET AL) 15 March 1994 see the whole document</p> <p style="text-align: center;">---</p>	1-5,7-11
X	<p>EP 0 618 612 A (MATSUSHITA ELECTRIC IND CO LTD) 5 October 1994 see claims 1-3,6</p> <p style="text-align: center;">---</p>	1-3,7-9
X	<p>US 5 326 490 A (MORI KIYOTO ET AL) 5 July 1994 see claims</p> <p style="text-align: center;">---</p>	1-3,7-9

INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/EP 97/01190

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 839 111 A (HAM E ET AL) 1 October 1974 see claims 1-3; example 2 ---	6,12
Y	US 4 585 515 A (MAA JER-SHEN) 29 April 1986 see column 2, line 51 - line 54 ---	6,12
A	US 5 292 402 A (ABT NORMAN E ET AL) 8 March 1994 see claim 9 ---	
P,X	DATABASE INSPEC INSTITUTE OF ELECTRICAL ENGINEERS, STEVENAGE, GB Inspec No. 5282506, MESSOUSSI R ET AL: "Improvement of rinsing efficiency after sulfuric acid hydrogen peroxide mixture (H/sub 2/SO/sub 4//H/sub 2/O/sub 2/) by HF addition" XP002035584 see abstract & JAPANESE JOURNAL OF APPLIED PHYSICS, PART 1 (REGULAR PAPERS & SHORT NOTES), APRIL 1996, PUBLICATION OFFICE, JAPANESE JOURNAL APPL. PHYS, JAPAN, vol. 35, no. 4A, ISSN 0021-4922, pages 1989-1992. ---	1-12
P,X, L	DATABASE WPI Section Ch, Week 9719 Derwent Publications Ltd., London, GB; Class L03, AN 97-211592 XP002035585 & TW 296 405 A (MERCK-KANTO ADVANCED CHEM LTD) , 21 January 1997 see abstract -----	1-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. al Application No

PCT/EP 97/01190

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0346668 A	20-12-89	JP 2034697 A	05-02-90
		US 4963283 A	16-10-90
US 5294570 A	15-03-94	EP 0477504 A	01-04-92
		JP 4234118 A	21-08-92
EP 0618612 A	05-10-94	CN 1096400 A	14-12-94
		JP 6333898 A	02-12-94
US 5326490 A	05-07-94	JP 2240285 A	25-09-90
		DE 69027266 D	11-07-96
		DE 69027266 T	02-10-96
		EP 0416126 A	13-03-91
		WO 9010730 A	20-09-90
US 3839111 A	01-10-74	AU 7229374 A	19-02-76
		BE 818991 A	16-12-74
		CA 1031250 A	16-05-78
		DE 2439300 A	06-03-75
		FR 2241876 A	21-03-75
		GB 1445659 A	11-08-76
		IN 139623 A	10-07-76
		JP 1165806 C	08-09-83
		JP 50073574 A	17-06-75
		JP 56033858 B	06-08-81
		NL 7410810 A	24-02-75
		SE 389427 B	01-11-76
		SE 7409819 A	21-02-75
US 4585515 A	29-04-86	NONE	
US 5292402 A	08-03-94	NONE	

THIS PAGE BLANK (USPTO)

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

THIS PAGE BLANK (USPTO)